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The purpose of this study was to investigate the relationship of twelve selected physical strength factors to the quality execution of the overhead volleyball pass. Sixty-seven seventh grade girls served as subjects. The selected physical strength factors included: wrist flexion, index finger extension, middle finger extension, thumb adduction, elbow extension, and shoulder flexion. Both the right and the left sides of the body were measured. The measurements were taken with a cable tensiometer.

The strength measurements were correlated with execution scores which were based on the quality of the contact with the ball during the performances of the overhead pass. Skill scores, based upon the alignment of body parts and the timing of the movement to meet the ball, were also given for the performances of the overhead pass. The skill scores were "partialed out" using a first order partial correlation technique. This technique allowed for the relationship between the strength factors and the execution scores to be determined without being influenced by the skill scores.

There was a slight degree of relationship found between the right and the left elbow extension strengths and the quality execution of the overhead volleyball pass. Index finger extension, middle finger extension, thumb adduction, wrist flexion, and shoulder flexion were not significantly related to the quality execution of the overhead pass.

A STUDY OF THE RELATIONSHIP OF SELECTED PHYSICAL STRENGTH FACTORS TO SUCCESS IN EXECUTING A QUALITY OVERHEAD PASS IN VOLLEYBALL FOR SEVENTH GRADE GIRLS

by

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CHAPTER I

INTRODUCTION

T. S. Eliot once said, "We shall not cease from exploration and the end of all our exploring will be to arrive where we started and know the place for the first time." This study was an exploration into the complexities of performing a motor skill. There are many factors which influence the performance of motor skills. Cratty has cited McCloy's list of ten factors which contribute to the performance of gross motor skills. These were compiled from a survey of studies. The factors were listed as:

1. Strength
2. Dynamic strength or energy
3. Ability to change direction
4. Flexibility
5. Agility
6. Peripheral vision
7. Good vision
8. Concentration
9. Understanding the mechanics of movements
10. Absence of disturbing emotional complications (4:219-220)

This study was primarily concerned with strength. Singer has said,

> "There is no doubt that in varying degrees, strength underlies all motor performance. In an isolated sense, strength may be thought of as the capacity of a muscle or group of muscles to exert maximum pressure against a given resistance in a limited period of time. A weakness in any area of the body may severly limit the coordination and effort needed for the performance of a skill. Thus, a minimum amount of strength is a necessity for motor performance." (12:57)

The question now becomes: Which strengths are important and what is the minimum amount of strength needed?

The investigator observed during her five years of teaching physical education at the junior high school level that many girls had difficulty playing the game of volleyball. The greatest difficulty was performing the overhead pass or volley. "Volleying," according to Dr. Cherebetiu, "is the foundation from which the whole game stems." (2:17) Danford has said, "If it is possible to say that any one skill in volleyball is more important than another, it is passing." (22:7) Meyer and Schwarz made this statement, "The volley is the basis of volleyball team play and should be developed immediately in the program for beginners." (9:374)

Volleyball has been most commonly introduced to children in the junior high school. It was the investigator's opinion that if a certain amount of strength was needed to perform a quality overhead pass, this would be a critical age. It was for this reason that the seventh grade was selected as the age group from which subjects were used for this study.

The role strength plays in volleyball has been assumed to be an important factor by many teachers, coaches and authors of volleyball books. This was evident in the conditioning exercises that have been used and recommended for this sport. Some of these have included: squeezing tennis balls, doing wrist curls with weights, playing catch with a weighted volleyball, doing finger push-ups, volleying a ball against

a wall 25 to 50 times in succession, and standing close to a wall, using only a wrist action to volley a ball. (7)(26)

STATEMENT OF THE PROBLEM

The purpose of this study was to investigate the relationship of twelve selected physical strength factors to success in executing a quality overhead pass in volleyball for seventh grade girls.

DEFINITION OF TERMS

For the purposes of this study, the following terms were defined:

Overhead pass - a two handed skill in volleyball in which the ball is contacted above, but in front of, the face. The ball should come in contact primarily with the thumbs, the index fingers and the middle fingers. The movement to meet the ball is simultaneous extension of the arms and legs. (25)

Quality pass - this is concerned with the finger contact with the ball. Three degrees of quality were considered for the overhead pass. A high quality pass was one in which the ball was given immediate impetus. A poor quality pass was one in which the ball was held in the hands before sending it into the air. (17) A medium quality pass was one in which the ball was not given immediate impetus to the degree of a high quality hit and yet not held in the hands as long as a poor quality hit.

ASSUMPTIONS UNDERLYING THE RESEARCH

For this study, it was assumed that:

1) The cable tensiometer was an accurate measure of static strength.

2) The volleyball chute consistently released the ball in the same place and with the same velocity.

SCOPE

This study was limited to sixty-seven subjects who were students in the seventh grade at Lindley Junior High School in Greensboro, North Carolina. All of the students were female.

The students were tested during their physical education class period. Four different classes, each meeting at a different time during the day, were used. The skill testing was completed in one day, but the strength testing was done over a period of two weeks. This was due to the amount of time it took to measure the strength factors for each subject and the length of time that could be used during the physical education class period.

CHAPTER II

REVIEW OF LITERATURE

There have been several attempts to explore the relationship between strength and volleyball skills. These have been reviewed in this chapter.

Slaymaker (31) conducted a study in which he compared selected physical characteristics of volleyball players at three different levels of competition. The levels included championship, tournament and class play. The test battery of physical characteristics were comprised of: leg power, agility, speed of arm movement, lateral speed of movement, height, reaction time, wrist flexibility, two-handed jumping ability, grip strength, and total body reaction time. The grip strength was measured with a hand dynamometer with a cable tensiometer attached. Each subject was given two trials with each hand. The scores from the selected physical characteristics were compared to the level of competition at which each subject played. Analysis of variance was used to determine if differences existing in mean scores of the various test items were significant. The Scheffe's F test was used to determine specific differences between groups. It was found that the championship group scored significantly higher than the tournament group in the two-handed vertical jump, the vertical jump, and the right hand grip strength. The

championship group scored significantly higher than the class group in the following tests: speed of hand movement, total body reaction time, two-handed vertical jump, vertical jump, right and left grip strength, and height. The tournament group scored significantly higher than the class group in only one test item, the two-handed vertical jump.

A study conducted by Bakker (18) entitled, "Factors Associated With Success in Volleyball", used 28 members of a women's extramural volleyball team as subjects. The factors measured were: height, weight, leg extensor strength, grip strength, skinfolds, jumping ability, and reaction and movement time. The leg extensor strength was measured using the Multiple Angle Testing Unit and the grip strength was measured with an adjustable hand dynamometer. The selected factors were correlated with ratings which were given to each subject on her playing ability. Correlations were used to show the degree of relationship between the selected factors and playing ability. The multiple correlation technique was also used to show the relationship between combinations of the physical factors and playing ability. It was found that jumping ability and reaction time were significantly related to success in volleyball.

Varichak (33) determined the relationship between certain fundamental physical abilities and ball handling skill in basketball and volleyball by comparing scores from a basketball speed pass test and a volleyball wall volley test

to grip strength for the hands, dexterity for the arms and hands, movement response for the arms, and reaction time for the hands and the arms. College men were used as subjects. The grip strength was taken with a hand dynamometer. The wall volley test was given by having the subject stand behind a line three feet away from the wall and on the signal "go," the subject volleyed the ball against the wall as many times as he could in ten seconds. The subject was also told to try to volley the ball above a line on the wall which was six feet and three inches from the floor. Hitting the ball above the line constituted a legal hit. The score was the total number of legal hits counted during the ten seconds. Correlation coefficients were computed between the physical abilities and the basketball and the volleyball skill scores. The correlations for the wall volley test were positive but rather low. The highest correlations were for the total arm movement response, strength of both hands together, and strength of each hand separately.

Lamp (23) investigated the relationship between the factors of chronological age, physiological age, height, weight, and grip strength to volleyball playing ability. Eight hundred and six boys and girls from the junior high school level served as subjects. Volleyball playing ability was determined by a battery of tests which included the serve, the volley, the set-up, and the net-pass. The elliptical hand dynamometer was used for measuring the grip strength of the right and the left hand. Correlations were used to show the relationship

between the various physiological factors and the four volleyball skill tests. It was found that there was no significant difference between the boys and the girls in their ability to perform skills of volleyball at this age. It was found that age and weight were more closely related for the girls than for the boys and height was more important for the boys than for the girls. For both the boys and the girls there was a slight positive relationship between strength and volleyball playing ability. It was also indicated that there was an improvement in playing ability with an increase in age.

Stauff (32) conducted a study on the effects of conditioning exercise upon the performance of the overhead pass. Seventh and eighth grade girls served as subjects. Four different conditioning exercises were used. These included squeezing an elliptical hand-dynameter, doing push-ups against a wall with the body supported by the fingertips, squeezing rubber balls, and volleying weighted balls over a twelve foot rope. The conditioning program was carried out in six class periods. The overhead pass skill test was one in which the subject stood behind a line, tossed the ball to self, and volleyed the ball over a rope which was at a twelve foot height and beyond a mark on the floor which was fifteen feet away from the subject. A two by two factorial analysis of variance was used to determine the effects of the conditioning in addition to skill practice. This analysis determined if there was a difference between the two approaches used to the

development of the overhead pass, if there was a difference between the two grade levels in the performance of the pass, and if differences between the two corresponding approaches were the same for both grade levels. It was found that the conditioning program in addition to the overhead pass practice was superior to pass practice alone. The eighth grade class was superior in passing ability but both grades were equally successful using the conditioning approach. Stauff made these recommendations for further study: 1) measure the amount of strength developed to determine how much strength was needed and which strengths were needed most, and 2) determine if the advantages gained through conditioning were long lasting.

Adam's (28) primary purpose for her study was to investigate the influence of lightweight plastic balls on teaching the overhead volley. An additional purpose of her study was to investigate the relationships between the following factors: 1) grip strength and finger strength, 2) grip strength and volley ability, and 3) finger strength and volley ability. Thirty-seven college women were used as subjects. The grip strength was measured with a dynamometer. Finger flexion and extension strengths, and thumb abduction and adduction strengths were measured with the cable tensiometer. All of the fingers were measured. The overhead pass was evaluated with the scores from a wall volley test. The Pearson Product-Moment Raw Score formula was used to determine the relationship between the factors listed above. It was

found that there was a moderate degree of relationship between finger strength and grip strength, there was a slight degree of relationship between the wall volley and grip strength, and there was a moderate degree of relationship between finger strength and the wall volley.

In summary, the literature seemed to indicate that there was a slight degree of relationship between grip strength and volleyball playing ability for men, college women, and junior high school boys and girls. Conditioning exercises for the fingers, wrists and arms seemed to improve the scores on an overhead volleyball pass test for junior high school girls. However, none of these studies indicated which strengths were most important.

CHAPTER III

PROCEDURES

SELECTION OF SUBJECTS

A letter of explanation and a request for permission to conduct this study was sent to the assistant superintendent of the Greensboro Public Schools in February, 1973. He responded favorably and then turned the request over to the supervisor of physical education who contacted the physical education instructor at Lindley Junior High School. The instructor was interested in the research and agreed to have her seventh grade classes participate in the study. The investigator met with each class at the end of March. She explained to the students the two types of tests they would be involved with and then asked the students who were willing to participate to fill out a card with their name and date of birth. A total of eighty-two girls from four classes were willing to participate in the study. However, fifteen students were eliminated during the course of the testing because of absenteeism, leaving sixty-seven girls to complete the testing.

The age range of the students tested was from twelve years and one month to fourteen years of age. All of the students had participated in a volleyball unit during the winter.

STRENGTH TESTING

The cable tensiometer (3) was used to measure strength. It was calibrated from 8 to 48 pounds. This was adequate for the muscle groups that were tested.

The selected physical strength factors that were tested included: thumb adduction, index finger extension, middle finger extension, wrist flexion, elbow extension, and shoulder flexion. These factors were decided upon after reviewing skill analyses of the overhead volleyball pass. McManama and Shondell stated, "The thumbs, index fingers and forefingers are the main contacting areas, with the ring fingers and the little fingers serving to stabilize the contact." (25:25) The force of the ball causes the fingers and the wrist to hyperflex as the arms flex for added absorption. "At the moment the ball is contacted, the levers of the fingers, wrist, elbow, hip, and knee joints are used in one synchronized movement which forces the ball to accelerate in the opposite direction." (25:25) This action can be clearly seen on a super 8 mm loop film of the overhead set available from the Athletic Institute. (27) Sandefur (10) and Anthony (1) have also analyzed the overhead volleyball pass in a similar fashion.

The muscle groups on both the right and the left sides of the body were measured. Two readings were taken of each of the muscle groups and then averaged. Two weeks were needed to complete this part of the study. An average of five students per class period were tested. The class periods were

forty-five minutes in length with seven minutes allowed at the beginning and the end of the hour for changing clothes. This left thirty-one minutes for testing. One student at a time was taken from the physical education class.

All of the measurements were taken with the subject seated in a school-type armrest chair. Two armrest chairs were used. One, with a right armrest, was used when measuring the right side of the body and the other, with a left armrest, was used for measuring the corresponding side of the body. Some of the positions for measuring strength were modified from those suggested by Clarke. (3) The positions which were modified were changed from a lying position on a testing table to a sitting position on a school-type armrest chair. The modifications were made to adapt to the testing situation at Lindley Junior High School. All of the positions have been pictured on pages 14-16 and those which were modified have been indicated. The position of the investigator was also drawn in to show how she isolated the muscle groups.

The subject was asked to sit with both feet flat on the floor, her back against the back of the chair and her unoccupied arm on her lap. Figure 1 shows the position for measuring thumb adduction. The subject's forearm rested on the armrest with the palm of the hand turned perpendicular to the armrest and the thumb up. The strap was placed around the thumb. The investigator isolated the thumb muscles by holding the forearm near the elbow and holding the fingers which prevented the arm

POSITIONS FOR TESTING STRENGTH

Figure 1

Thumb adduction

Figure 2

Index finger and middle finger extension*

*Denotes modified position

Figure 3

Wrist flexion*

Figure 4

Elbow extension*

Figure 5

Shoulder flexion*

from moving forward or lifting up. The subject was asked to adduct the thumb by pressing toward the armrest.

Figure 2 shows the position for measuring index finger and middle finger extension strength. The elbow rested on the armrest. The wrist was bent back and the canvas strap was placed around the finger. The investigator isolated the finger by putting pressure on the subject's palm, preventing the wrist from flexing, and holding the forearm in place to prevent the elbow from extending or moving forward. The subject was asked to extend the finger by pressing against the strap.

Figure 3 shows the position for measuring wrist flexion strength. The elbow rested on the armrest. The wrist was bent back and the canvas strap was attached around the fingers and the thumb. The investigator isolated the wrist joint by holding the forearm just below the wrist to prevent elbow extension, and by holding the upper arm close to the elbow to prevent movement at the shoulder joint. The subject was asked to flex the wrist by pressing against the strap.

Figure 4 shows the position for measuring elbow extension strength. The elbow rested on the armrest and was bent at approximately a 40° angle. The palm of the hand was turned away from the subject. The strap was placed around the wrist. The investigator isolated the elbow joint by holding the upper arm close to the elbow, preventing shoulder flexion or extension, and by pressing down on top of the shoulder,

preventing it from lifting. The student was asked to extend the elbow by pressing forward with the upper arm.

Figure 5 shows the position for measuring shoulder flexion. The elbow was bent and rested on the armrest. The strap was attached to the upper arm close to the elbow. The investigator isolated the shoulder joint by pressing down on top of the shoulder, preventing it from lifting, and holding the forearm, keeping the elbow joint in position. The student was asked to flex the shoulder joint by swinging the elbow forward.

In all of the positions the subject applied steady pressure against the strap until the pointers on the tensiometer no longer moved forward. The student was then asked to release the contraction and the reading was taken from the maximum pointer which marked the point of the greatest muscle contraction.

As was suggested by Clarke (3), the strap and chain were attached at a right angle to the body segment to which it was connected. The other end of the chain was attached to one of a series of six hooks that were evenly spaced and mounted on a two inch by two inch board. The board was five feet in length. It was secured to a wrought iron railing that was located in the gymnasium at Lindley Junior High School.

A student from each of the four classes was taught how to use and read the cable tensiometer. The investigator attached the strap around the subject's body segment,

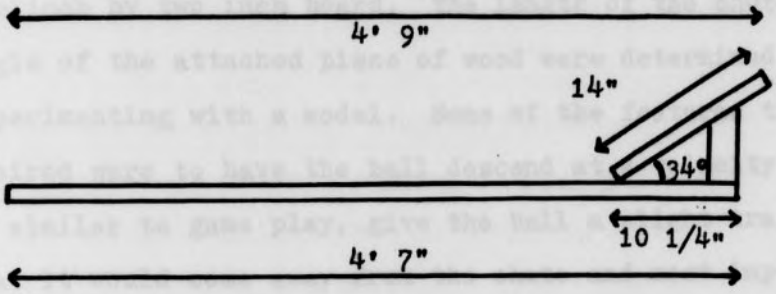
instructed the subject how to move the joint, and then isolated the muscle groups. The student assistant took the reading from the tensiometer. The investigator positioned herself next to the student in such a way that errors in reading the strength scores could be detected. The second reading was taken immediately following the first and both scores were recorded by the investigator. (A sample of the score sheet is included in the appendix on page 42.)

TESTING DEVICE FOR THE OVERHEAD PASS

In order to control the placement for receiving the ball for each execution of the overhead pass, a chute was designed and constructed to release the ball with consistent speed and accuracy. The reliability of the chute was tested by releasing a chalked volleyball ten times. The chute was set at the same height used in the testing situation. A sheet of blue construction paper was placed on the floor and held in place by an assistant who also returned the ball after it made its mark. The marks left on the paper indicated almost perfect placement of the ball. Two of the balls made marks that were one quarter of an inch to the right of the other marks.

The chute was built from plywood, galvinized aluminum and flat rubber coated double copper wire. Diagrams of the chute with dimensions have been included on page 20. Five ply plywood was used for the frame. The total length of the wood structure was four feet and nine inches. The width was six

DIAGRAMS OF CHUTE WITH DIMENSIONS



Scale: one inch equals one foot

Scale: two inches equals one foot

Scale: one inch equals one and one half feet

inches. A fourteen inch piece of plywood was placed ten and one half inches from the end at a 34° angle and braced with a two inch by two inch board. The length of the chute and the angle of the attached piece of wood were determined after experimenting with a model. Some of the features that were desired were to have the ball descend at a velocity that would be similar to game play, give the ball a slight trajectory so that it would come away from the chute and most important, release the ball with consistent velocity and accuracy.

A strip of galvinized aluminum, five inches wide, was nailed to the frame to make the surface smooth and to form a curve at the joint of the two pieces of wood. Two half inch high tracks were nailed to the aluminum and the wood with three and five eighths of an inch between them. The tracks were made from rubber coated double copper wire and two thicknesses were used for each track. The tracks held the ball in line and prevented movement from side to side.

A piece of wood was added to the back end of the chute. The ball was held against this piece of wood to assure a consistent point of release each time. The ball was held with one hand and released by raising the hand quickly upward.

A pilot study was conducted in February, 1973 at the University of North Carolina at Greensboro. The chute was mounted on a volleyball official's ladder which was placed on top of bleachers. The back end of the chute leaned against the wall at a 45° angle. The height, which was measured from the lip of the chute to the floor, was seven feet and five inches.

It was found during the pilot study that a greater height was needed for taller subjects. The height was adjusted to eight feet and five inches for the students at Lindley Junior High School.

During the actual experimentation the chute was stabilized on a chair. Blocks of wood were nailed to the chair, preventing the chute from moving sideways or forward. The bottom support was also tied down which prevented the chute from lifting up if hit by the ball. The chair with the attached chute was then placed on top of a table and the table placed on the edge of a stage in the gymnasium. The position of the chair on the table was marked as well as the position of the table on the stage to insure that the equipment was in the same place for all of the classes.

OVERHEAD VOLLEYBALL PASS TRIALS

Each student was given six practice trials before the trials for the study to familiarize her with the chute. Three classes practiced two days before and one class practiced one day prior to the testing day.

The same instructions for the execution of the overhead volleyball pass and the use of the chute were given to each class. These were as follows:

> The knees are bent. One foot is in front of the other with the weight evenly distributed over both feet. The trunk is held upright. The elbows are bent and turned slightly outward. The hands are above and in front of the face with the fingers slightly spread. The wrists are bent back slightly. The action is the simultaneous extension of

> the arms and legs in the direction the ball is to be sent. The extension begins when the ball is about two feet in front of the face. The ball is contacted primarily with the thumbs, index fingers and middle fingers.

After the explanation was given, the students practiced this action several times. The investigator then explained how the chute was used. This was given as follows:

> Position yourself in front of the chute with your forward foot toeing the tape mark.

A strip of masking tape was placed on the floor to indicate the approximate place where the student would stand. If adjustments were necessary these were made during the practice trials.

> I will call out "ready" before the ball is released. Assume your ready position with your knees bent and your arms and hands in position. When you are ready, the ball will be released. When the ball is about two feet in front of your face, extend to meet it.

On the testing day, each student was given three practice trials and then three trials for the skill score and five trials for the execution score. (The skill score and the execution score are explained on pages 24-26.) All of the trials were given successively for each student. The skill score trials and the execution score trials were videotaped on a Sony camera. A portable tape deck was used. The camera was mounted on a tri-pod. This equipment was handled by one of two assistants from the University of North Carolina at Greensboro who were trained to use the camera and tape equipment. All of the taping was done on the same day.

During the performance of the skill score trials, the camera was focused on the total body. The lens was zoomed in

on the upper body for the execution score trials. The students were identified by previously assigned numbers which were displayed on a clip board and in view of the camera.

Three balls were used for the testing so there was no delay between trials. The balls were the property of the university. They were identical brands and each ball was inflated to the manufactured suggested air pressure of seven pounds. Student assistants helped to retrieve the balls during the testing.

The video tapes were brought back to the university where they were viewed and scored by three raters. The raters had been involved in the pilot study and had discussed and practiced the rating system for the skill scores and the execution scores. All three raters were DGWS national volleyball officials. All three had taught volleyball at various levels including the junior high school. Two of the raters had coached both high school and college volleyball teams and the third rater had played for several years on an AAU volleyball team.

The tapes were viewed in a two and a half hour session. The tape was replayed any number of times at the request of a rater, but only for that subject who was being viewed at the time. The tape of a previous subject was not replayed.

The skill scores, which were given for the first three trials, were based upon the timing and alignment of body parts during the execution of the overhead pass up until contact with

the ball. The timing of the overhead volleyball pass included the following parts:

1. simultaneous extension of the arms and legs when extending to meet the ball
2. correct speed of extension for effective use of force
3. proper timing of the extension in relationship to the ball

The alignment aspect of the skill scores was based on the body parts being in the correct position throughout the extension.

The raters were supplied with a specially prepared score sheet. (A sample appears in the appendix on page 43.) The raters were instructed to score the skill score trials by placing the letter T in the appropriate square if any part of the timing was incorrect. The letter A was used to indicate incorrect alignment of body parts, and both the letters T and A were written in the square if both aspects were incorrect. The square was left blank if both the timing and the alignment were correct.

Later these notations were converted to numerical values. If the square was blank, two points were given. If the square contained either the letter T or A, one point was given, and if the square contained both the letters T and A, zero points were given. The three scores from each of the three raters were totaled to comprise the final skill score.

The execution scores, which were given for the last five trials, were based upon the quality of the hand contact with the ball. Three degrees of quality were scored using a three point scale. Three points were given for a high quality hit, two points for a medium quality hit, and one for a poor quality hit. The quality of the hit was assessed according to the degree of legality. A high quality hit was a legal hit in which the ball was given immediate impetus with the fingers. (17) A poor quality hit was an illegal hit in which the ball was held in the hands before sending it into the air. (17) A medium quality hit was one in which the ball was not given immediate impetus to the degree of a high quality hit and yet not held in the hands as long as a poor quality hit. The five scores from each of the raters were totaled to comprise the final execution score.

TREATMENT OF DATA

The partial correlation technique was used to determine the relationship of each of the strength variables to the execution scores while holding the skill scores constant. The data were prepared for computer analysis and then submitted to an IBM 360 computer for processing.

CHAPTER IV

ANALYSIS OF DATA

Twelve physical strength factors were measured for each of the sixty-seven students who served as subjects. These factors have been listed in Table I on page 28 along with their means and standard deviations. In addition, the means and standard deviations for the skill scores and the execution scores were listed. (The raw scores for each of the subjects has been included in the appendix on pages 47-53.) The scores for the strength factors were taken directly from the readings on the cable tensiometer. These readings were not converted to pounds of pressure for analysis. However, a table of calibrations has been included in the appendix on page 44. Since there were no known norms established for strength measurements for junior high school students, a comparison of means could not be made.

A first order partial correlation technique was used to determine the relationship of the selected physical strength factors to the performance of a quality overhead volleyball pass. This technique allowed for the skill scores for each student to be "partialed out" so that the relationships between the physical strength factors and the quality of the overhead volleyball pass would not be influenced by timing and alignment of body parts.

TABLE I

MEANS AND STANDARD DEVIATIONS

Variable	Mean*	Standard Deviation*
1. Right Wrist	11.5373	5.4804
2. Left Wrist	10.9291	5.1619
3. Right Index Finger	3.8209	2.3879
4. Left Index Finger	3.3284	2.3356
5. Right Middle Finger	3.7910	2.6399
6. Left Middle Finger	3.3657	2.5489
7. Right Shoulder	15.9963	5.7352
8. Left Shoulder	15.8396	5.3521
9. Right Elbow	12.9925	5.6172
10. Left Elbow	12.3657	4.5636
11. Right Thumb	6.1261	2.4883
12. Left Thumb	5.9590	2.6988
13. Skill Score	13.7910	2.9875
14. Execution Score	31.4552	6.0382

*Mean and standard deviation values for variables 1-12 are in cable tensiometer units.

Intercorrelations between all of the strength variables were computed. (These appear in the appendix on page 45.) It should be noted that the correlation coefficients between the right index finger and the right middle finger and between the left index finger and the left middle finger were .81 and .71 respectively. These coefficients were not only significant at the five per cent level of confidence but showed a fairly high relationship. This would seem to indicate, for future studies of this type, that only one of the measurements for finger strength would have to be taken on each side of the body.

The correlation coefficients between the strength scores and the skill scores, and the strength scores and the execution scores were also computed. These appear in Table II on page 30. All of the correlations between the strength scores and the execution scores were low and positive. However, only four of the correlations were significant at the five per cent level of confidence. These were: .3067 for the left elbow; .2948 for the right elbow; .2684 for the right shoulder; and .2661 for the left middle finger.

The correlations between the strength variables and the skill scores were also low and positive. However, only one coefficient was significant at the five per cent level of confidence. This was .3280 for the right shoulder.

The correlation coefficients between the strength variables and the execution scores were higher than the

TABLE II

INTERCORRELATIONS OF THE STRENGTH FACTORS
WITH THE EXECUTION SCORES AND THE SKILL SCORES

Strength Factor	Execution Score	Skill Score
1. Right Wrist	.0919	.0167
2. Left Wrist	.1605	.1005
3. Right Index Finger	.0846	.0287
4. Left Index Finger	.1928	.1397
5. Right Middle Finger	.1577	.0957
6. Left Middle Finger	.2661*	.1485
7. Right Shoulder	.2684*	.3280*
8. Left Shoulder	.2041	.2163
9. Right Elbow	.2948*	.1119
10. Left Elbow	.3067*	.0546
11. Right Thumb	.1109	.0599
12. Left Thumb	.1402	.0840
13. Skill Score	.5248*	

*Significant at the five per cent level of confidence

correlation coefficients between the strength variables and the skill scores with the exceptions of the right and the left shoulder flexion strengths. This would seem to indicate that the strength factors were more closely related to the execution of a quality overhead pass than they were to the timing and/or alignment of body parts. The exception was shoulder strength which seemed to be more closely related to the timing and/or alignment of body parts.

There was one other coefficient of concern which was significant at the five per cent level of confidence. This was the correlation between the skill scores and the execution scores. A coefficient of .5248 was found which showed a moderate but substantial relationship. This correlation was higher than any of the correlations between the strength variables and the execution scores. This would seem to indicate that the execution of a quality overhead pass was more closely related to timing and alignment of body parts than it was to any of the strength factors.

After using the first order partial correlation technique, correlating each of the strength variables with the execution scores while holding the skill scores constant, it was found that only two coefficients remained significant at the five per cent level of confidence. These correlations were for the right and the left elbow, with the coefficients of .2791 and .3272 respectively. (See Table III on page 32.) All of the partial correlation coefficients have been included in Table III.

TABLE III

FIRST ORDER PARTIAL CORRELATIONS

r1.14:13	r2.14:13	r3.14:13	r4.14:13
.0976	.1272	.0817	.1418
r5.14:13	r6.14:13	r7.14:13	r8.14:13
.1268	.2236	.1196	.1090
r9.14:13	r10.14:13	r11.14:13	r12.14:13
.2791*	.3272*	.0935	.1133

*Significant at the five per cent level of confidence

VARIABLES

1. Right Wrist
2. Left Wrist
3. Right Index Finger
4. Left Index Finger
5. Right Middle Finger
6. Left Middle Finger
7. Right Shoulder
8. Left Shoulder
9. Right Elbow
10. Left Elbow
11. Right Thumb
12. Left Thumb
13. Skill Score
14. Execution Score

It should be noted, only two of the correlations increased after "partialing out" the skill scores. These were the correlations for the right wrist and the right elbow. All of the other correlations decreased. This would seem to suggest that the skill scores or the timing and/or alignment of body parts had an influence on the execution of a quality overhead pass.

The findings of this study were in agreement with most of the other studies which investigated the relationships of various strength factors to volleyball skill tests and to playing ability. (18)(23)(28)(31)(33) It was found in these studies that there were only slight relationships. This study seemed to dispute Stauff's (32) study in which she found that strength conditioning exercises increased the performance on an overhead volleyball pass skill test. However, since Stauff had not determined if there was a change in strength after completing the strength conditioning exercises, the effect strength had on improving the overhead pass test had not been determined.

The findings of this study would seem to suggest to the physical education teacher that strength is not an important factor for success in executing a quality overhead volleyball pass for seventh grade girls. More time should probably be spent developing other factors that are more important to the overhead volleyball pass. The question still exists: What are the factors that are most important to the successful execution of the overhead pass?

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

This study was conducted to investigate the relationship between twelve selected physical strength factors and the quality execution of the overhead volleyball pass. Sixty-seven seventh grade girls from Lindley Junior High School in Greensboro, North Carolina served as subjects.

A first order partial correlation technique was used to analyze the data. The strength factors were correlated with the execution scores which were based upon the quality of the hand contact on the ball during the execution of the overhead pass. The variables which were "partialed out," the skill scores, were based on timing and alignment of body parts during the extension phase of the overhead pass. It was found that there was very little relationship between the strength factors and the execution of a quality overhead volleyball pass. In other words, a greater amount of strength did not mean a higher quality execution of the overhead pass. Only two strength factors were significant at the five per cent level of confidence. These were the coefficients for the right and the left elbow extension strengths.

It was found from the intercorrelations of all the variables that most of the strength factors were more closely

related to the execution scores than they were to the skill scores. The exception was shoulder strength. Both the right and the left shoulder flexion strengths were more closely related to the skill scores or the timing and alignment of body parts during the extension phase of the overhead pass.

It was noted that the correlation found between the skill scores and the execution scores showed a moderate relationship. This was greater than the relationships found between the strength variables and the execution scores. This seemed to suggest that perhaps the timing and/or alignment of body parts was more closely related to the quality execution of an overhead pass than the strength factors.

The correlations between the right index finger and the right middle finger and between the left index finger and the left middle finger were high enough to recommend for future studies, measuring either just index finger strength or just middle finger strength.

CONCLUSIONS

Within the limitations of this study, the following conclusions seem warranted:

1) Index finger extension, middle finger extension, thumb adduction, wrist flexion, and shoulder flexion strengths are not significantly related to the quality execution of the overhead volleyball pass.

2) There is a slight degree of relationship between the elbow extension strengths and the quality execution of the overhead volleyball pass.

RECOMMENDATIONS FOR FURTHER STUDY

The investigator would suggest that additional study be done investigating the relationship of other variables such as timing and/or alignment of body parts to the quality execution of the overhead volleyball pass. An investigation of this type could involve slow motion photography. This study could also include the strength factors to see if a combination of variables would have a greater relationship to the quality execution of the overhead volleyball pass.

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APPENDIX

SAMPLE SCORE SHEET FOR STRENGTH MEASUREMENTS

S	Wrist		Index F.		Middle F.		Shoulder		Elbow		Thumb	
	R	L	R	L	R	L	R	L	R	L	R	L
1												
2												
3												
4												
5												

SAMPLE RATING SHEET FOR THE SKILL SCORE TRIALS

AND THE EXECUTION SCORE TRIALS

S	Skill Score				Execution Score				
	1	2	3		1	2	3	4	5
1									
2									
3									
4									
5									
6									
7									

CALIBRATIONS OF CABLE TENSIOMETER UNITS INTO POUNDS OF PRESSURE

UNITS	POUNDS	UNITS	POUNDS
1	8	17	29
2	10	18	31
3	12	19	32
4	14½	20	34
5	16	21	35
6	17	22	36
7	18	23	38
8	19	24	39
9	21	25	41
10	22	26	42
11	23	27	43
12	24	28	45
13	25	29	46
14	26	30	47
15	27	31	48
16	28		

INTERCORRELATIONS OF THE STRENGTH FACTORS

	2	3	4	5	6	7	8	9	10	11	12
1	.5573*	.5446*	.5805*	.6031*	.5244	.3164*	.1749	.6185*	.3334*	.4462*	.4418*
2		.4182*	.5963*	.5114*	.6576*	.3239*	.2312	.6439*	.5486*	.4810*	.5728*
3			.5303*	.8200*	.4195*	.2504*	.1007	.5405*	.3554*	.4211*	.3519*
4				.5888*	.7124*	.3460*	.2778*	.5068*	.5551*	.3065*	.4805*
5					.5557*	.3378*	.2013	.6096*	.4953*	.5393*	.4491*
6						.4169*	.2007	.5761*	.5125*	.4500*	.4714*
7							.5204*	.4747*	.4366*	.0798	.2246
8								.2594*	.4542*	.0258	.2791*
9									.6687*	.5294*	.3825*
10										.4467*	.4694*
11											.5730*

*Significant at the five per cent level of confidence

(A list of the strength factors appears on the following page.)

STRENGTH FACTORS

1. Right Wrist
2. Left Wrist
3. Right Index Finger
4. Left Index Finger
5. Right Middle Finger
6. Left Middle Finger
7. Right Shoulder
8. Left Shoulder
9. Right Elbow
10. Left Elbow
11. Right Thumb
12. Left Thumb

RAW SCORES FOR THE TEST VARIABLES*

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
1.	Right	5.50	2.25	1.50	17.00	8.00	3.50	14	25.00
	Left	9.75	1.50	1.00	17.00	15.00	4.75		
2.		7.00	2.50	3.00	14.75	12.50	5.00	16	41.00
		8.50	2.50	2.50	17.00	12.00	3.75		
3.		7.00	0.00	1.00	14.00	3.75	3.50	17	26.00
		7.00	.75	.50	20.00	8.50	4.00		
4.		25.00	10.75	9.50	29.25	28.00	8.50	14	37.00
		24.75	8.50	8.50	40.75	17.00	11.75		
5.		13.00	3.00	2.50	18.75	16.00	3.50	18	36.00
		11.75	3.25	4.50	20.50	12.00	4.75		
6.		10.50	3.25	3.25	16.50	7.50	7.50	17	27.00
		5.00	2.50	4.00	13.25	9.75	7.50		
7.		8.50	7.00	5.50	10.50	12.50	6.75	16	43.00
		4.50	8.50	6.50	20.00	16.50	8.50		
8.		12.00	2.75	3.25	19.25	17.00	7.75	16	41.00
		11.00	4.50	3.75	14.50	13.50	6.00		
9.		7.75	3.00	1.50	16.50	15.75	7.75	14	33.00
		9.50	2.50	3.25	18.75	17.75	3.75		
10.		13.50	3.00	2.75	21.00	9.00	6.75	16	32.00
		7.25	3.50	3.50	15.00	14.50	3.50		
11.		11.50	3.50	3.25	18.75	15.50	5.50	18	42.00
		13.75	2.75	1.75	19.00	15.75	3.75		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
12.	Right	16.00	10.00	6.50	15.00	21.75	12.00	17	33.00
	Left	16.50	3.50	4.25	10.50	13.50	4.50		
13.		14.25	4.50	4.00	17.25	17.75	3.50	13	25.00
		14.75	5.75	3.50	19.75	13.50	3.75		
14.		24.50	11.50	12.00	25.00	19.25	9.25	16	30.00
		18.50	9.00	5.00	20.00	20.00	14.50		
15.		13.75	7.75	8.00	24.75	18.00	9.50	16	29.00
		16.25	3.50	8.00	26.75	13.50	7.50		
16.		11.50	4.00	5.75	14.50	13.75	3.75	16	25.00
		12.25	.50	1.00	11.50	9.00	2.25		
17.		18.00	1.50	2.00	14.00	10.50	9.00	14	30.00
		9.00	2.75	3.25	12.50	4.25	8.50		
18.		19.50	4.50	3.00	17.75	19.50	4.25	16	27.00
		16.25	2.50	2.75	18.00	8.75	9.50		
19.		5.00	2.25	2.00	20.50	11.00	4.00	16	32.00
		11.50	2.50	2.50	15.00	8.25	5.50		
20.		6.50	3.00	2.00	17.50	8.50	3.00	17	39.00
		10.00	1.50	3.50	13.50	9.00	3.00		
21.		14.50	2.25	3.75	10.50	7.00	2.75	14	33.00
		5.50	2.50	1.25	15.50	7.00	2.50		
22.		4.00	2.00	.50	5.75	4.00	3.00	14	39.00
		5.00	0.00	0.00	10.50	4.75	3.00		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
23.	Right	2.00	2.00	5.00	30.50	20.00	7.00	15	35.00
	Left	18.00	6.50	5.50	26.50	29.25	7.00		
24.		5.50	2.00	2.00	6.00	10.75	6.50	14	26.00
		11.25	.75	1.50	10.50	9.00	5.00		
25.		13.00	4.25	1.00	8.25	13.50	6.00	15	29.00
		18.50	6.50	5.50	14.50	13.25	7.75		
26.		13.50	3.25	3.25	19.50	8.50	6.25	17	29.00
		9.00	3.50	3.00	27.00	13.50	9.75		
27.		17.75	1.50	2.50	23.00	15.50	10.50	16	39.00
		10.50	1.50	1.00	17.75	15.50	7.50		
28.		9.00	1.75	1.75	12.00	12.00	5.50	15	42.00
		9.50	.75	0.00	13.00	12.00	7.50		
29.		10.50	5.00	8.50	25.25	23.25	10.75	16	38.00
		24.00	4.00	12.50	23.75	21.00	12.00		
30.		5.50	2.50	2.50	15.75	6.25	4.50	16	30.00
		6.25	3.00	2.50	12.75	8.50	4.00		
31.		14.50	4.50	3.50	17.75	11.25	7.50	16	27.00
		11.75	6.25	3.75	18.00	11.25	7.75		
32.		14.00	3.25	2.50	20.75	13.00	3.75	15	32.00
		7.00	4.00	5.00	16.75	15.75	4.00		
33.		19.00	6.50	9.50	12.50	20.75	9.25	13	35.00
		8.25	4.00	3.50	14.25	19.50	4.25		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
34.	Right	12.75	3.25	2.50	18.00	12.50	7.25	14	30.00
	Left	16.00	2.75	1.50	16.50	12.75	8.75		
35.		13.00	4.25	6.75	20.50	11.50	7.50	16	41.00
		14.25	5.00	6.25	11.50	13.00	8.50		
36.		30.00	4.50	7.50	19.00	26.00	8.50	16	42.00
		25.50	11.25	15.00	13.50	19.00	7.75		
37.		8.00	4.00	3.25	13.00	12.00	6.25	18	41.00
		10.00	2.00	2.00	13.50	9.50	4.25		
38.		5.00	1.00	1.25	16.00	7.00	4.00	15	38.00
		6.25	1.00	3.75	8.00	7.50	4.00		
39.		5.50	.75	1.50	12.00	10.00	3.50	17	29.00
		6.25	.50	1.00	11.25	9.50	4.00		
40.		11.50	6.00	6.75	17.00	6.25	6.00	15	31.00
		20.50	8.00	4.25	24.00	11.75	8.25		
41.		9.50	3.75	4.50	19.00	17.00	4.50	17	38.00
		8.00	4.00	1.25	29.50	12.50	4.25		
42.		4.75	3.50	3.50	8.00	8.00	4.00	14	32.00
		5.75	1.50	.50	10.75	9.00	4.50		
43.		7.50	3.50	3.50	13.50	10.25	3.75	14	35.00
		7.50	3.75	2.50	15.50	10.00	4.50		
44.		6.00	1.75	1.50	18.50	12.00	7.50	13	33.00
		4.00	2.00	2.50	10.00	9.50	7.50		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
45.	Right	6.50	2.50	1.50	15.00	10.50	3.00	11	25.00
	Left	5.00	2.00	1.00	8.00	5.50	3.00		
46.		10.00	2.50	2.00	12.50	8.00	3.50	5	27.50
		14.00	3.50	2.50	14.50	17.00	8.00		
47.		12.00	2.25	1.00	22.75	17.50	4.00	13	38.00
		7.00	1 75	1.50	32.00	14.50	8.00		
48.		12.50	3.00	5.00	8.50	25.00	11.50	12	32.00
		17.50	2.50	3.50	14.50	19.75	11.00		
49.		18.50	6.50	9.50	19.00	19.50	5.50	13	32.00
		14.00	9.00	5.50	20.00	18.50	7.50		
50.		4.50	4.50	2.75	10.00	4.50	4.50	9	22.00
		4.75	1.75	1.50	13.00	6.50	.50		
51.		15.50	2.75	3.50	9.00	9.00	8.00	10	32.00
		12.00	3.00	5.00	21.00	17.00	11.50		
52.		10.50	2.50	1.50	12.25	11.50	3.75	9	22.00
		7.25	2.00	2.50	7.75	7.50	3.25		
53.		11.50	3.25	3.75	23.50	13.00	3.75	12	33.00
		7.00	1.00	3.00	14.50	10.75	4.00		
54.		12.75	6.50	5.75	16.50	18.25	8.00	6	29.00
		12.50	1.50	3.00	18.75	17.00	6.75		
55.		17.50	4.75	4.25	6.50	16.50	11.25	8	24.00
		15.25	4.50	4.00	13.50	12.50	5.00		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
56.	Right	13.00	4.50	3.00	27.50	17.00	5.00	13	26.00
	Left	8.00	4.00	5.50	18.00	11.50	3.50		
57.		4.00	1.75	0.00	5.00	4.50	4.50	7	19.00
		4.00	1.00	1.50	7.00	9.75	3.25		
58.		16.00	4.75	4.00	9.00	10.75	5.50	11	30.00
		15.50	4.25	3.75	13.00	11.00	8.25		
59.		9.00	2.50	2.50	10.50	9.50	7.50	13	23.00
		12.25	3.00	2.50	10.75	10.25	7.50		
60.		3.00	2.00	2.00	7.00	7.00	6.50	12	24.00
		8.75	3.00	2.50	6.50	11.00	6.00		
61.		15.50	3.50	3.25	19.75	19.00	4.75	12	24.00
		9.00	5.00	2.50	16.75	17.50	4.75		
62.		14.00	3.25	3.00	20.25	5.00	3.00	12	28.00
		7.25	1.25	2.00	20.50	8.50	3.50		
63.		13.75	4.00	3.50	13.00	14.00	7.50	10	31.00
		16.00	1.50	2.25	13.50	11.25	3.75		
64.		14.50	5.50	9.50	11.50	11.50	11.00	12	21.00
		6.50	2.00	3.00	12.50	7.00	7.00		
65.		13.75	12.00	9.00	16.00	17.75	5.50	12	34.00
		6.50	3.00	2.75	12.50	14.25	4.00		
66.		13.75	1.75	2.75	19.25	12.50	3.00	7	24.00
		11.00	3.75	3.75	20.25	7.75	2.25		

RAW SCORES FOR THE TEST VARIABLES* (continued)

		Wrist	Index F.	Middle F.	Shoulder	Elbow	Thumb	Skill	Execution
67.	Right	4.50	2.50	0.00	13.00	5.00	3.00	13	30.00
	Left	5.00	1.50	1.50	14.00	6.00	3.25		

*The strength scores are the average of two readings taken from the cable tensiometer and recorded in cable tensiometer units. The skill scores are the total of nine scores for the performances of three overhead volleyball passes as they were scored by three raters. The execution scores are the total of fifteen scores for the performances of five overhead volleyball passes as they were scored by three raters.